Amputations in U.S. Military Personnel in the Current Conflicts in Afghanistan and Iraq

Lynn G. Stansbury, MD, MPH, FACP, Steven J. Lalliss, MD,* Joanna G. Branstetter, MD,† Mark R. Bagg, MD,† and John B. Holcomb, MD, FACS**

Objectives: To determine rates of major limb amputation in U.S. military casualties in the current conflicts in Afghanistan and Iraq, to correlate these with mechanism of injury, and compare the rate with that seen in U.S. casualties from the Vietnam War.

Design: Retrospective study of all U.S. casualties recorded for the current conflicts from the start in October 1, 2001 to June 1, 2006.

Setting: Records from U.S. military forward surgical teams (Level IIb) and combat support hospitals (Level III) in theater, evacuation (Level IV, Germany), and major military medical centers (Level V, United States).

Patients/Participants: All recorded U.S. military casualties from the Afghanistan and Iraq theaters with injuries requiring evacuation out of theater or prohibiting the individual from returning to duty for more than 72 hours.

Intervention: None.

Main Outcome Measurements: Major limb injury, level of amputation, principal mechanism of injury.

Results: Over the past 56 months, of the 8058 military casualties meeting the listed criteria, 5684 (70.5%) were recorded as having major limb injuries. Of these, 423 (5.2% of all serious injuries; 7.4% of major limb injuries) underwent major limb amputation or amputation at or proximal to the wrist or ankle joint. The mechanism of injury for 87.9% was some form of explosive device. The major amputation rate during Vietnam was 8.3% of major limb injuries.

Conclusions: Overall, major limb amputation rates for the current U.S. engagement in Afghanistan and Iraq are similar to those of previous conflicts.

Key Words: trauma epidemiology, amputation rate

(*J Orthop Trauma* 2008;22:43–46)

Accepted for publication September 14, 2007.

From the U.S. Army Institute of Surgical Research Extremity Trauma Soft-tissue Branch, Fort Sam Houston, Texas; and †Brooke Army Medical Center Department of Orthopaedics, Fort Sam Houston, Texas.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or United States government. The authors are employees of the U.S. government and this work was prepared as part of their official duties.

Reprints: Joanna G. Branstetter, MD, Brooke Army Medical Center Department of Orthopaedics, 3851 Roger Brooke Dr., Fort Sam Houston, Texas 78234 (e-mail: Joanna.Branstetter@amedd.army.mil).

INTRODUCTION

Major limb amputations are among the most debilitating wounds sustained by those who survive a combat injury, and these injuries leave a lasting impression with the public. Since the beginning of the current conflicts in Afghanistan and Iraq, concerns have been raised in the media and by medical personnel that amputation rates are higher than for previous conflicts. Previously, epidemiologic assessment of military casualties was possible only after the end of a given conflict because a database was initiated after the conflict was over. However, in 2002 the Joint Theater Trauma Registry (JTTR) was established at the U.S. Army Institute of Surgical Research (USAISR) at Fort Sam Houston, Texas, as a pioneering effort to collect, store, and analyze all-service casualty data as they became available. As of November 1, 2006, data entry summarizing the records on U.S. casualties from October 1, 2001 through June 1, 2006 was essentially complete. In addition, the USAISR is the repository of data available through the military specialty rehabilitation centers located in the continental United States. These data sets allow preliminary, evidence-based review of major limb amputations. The purpose of the paper is to provide the rate of major limb amputation as it compares with all serious injuries and with all serious extremity injuries.

PATIENTS AND METHODS

Current Data

The JTTR was searched for all U.S. military casualties from the onset of the conflict on October 1, 2001 to June 1, 2006. All casualties with minor injuries not requiring evacuation out of theater or who were returned to duty within 72 hours were excluded. From this group, the subset of individuals with major-extremity injuries was identified via ICD-9 codes, excluding those with superficial injuries and/or injuries only involving fingers or toes. Detailed data on amputees, including anatomic location of amputation or amputations and mechanism of injury, were identified using the database maintained by the Military Amputee Research Program (MARP). A major amputation was defined as loss of a limb at or proximal to the wrist or ankle. For the calculation of proportions of major upper- or lower-extremity injuries that resulted in amputation, an individual with both upper- and lower-extremity injury was represented in each denominator one time. Otherwise, rates and proportions are calculated on the basis of individual amputees, not amputations. Of the amputees (MARP), 62.4% were recorded as having sustained battle injuries, and of all casualties (JTTR), 65.8% were

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JAN 2008	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Amputations in U.S. military personnel in the current conflicts in Afghanistan and Iraq	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Stansbury L. G., Lalliss S. J., Branstetter J. G., Bagg M. R., Holcomb J. B.,	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX 78234	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**4**	

recorded as having sustained battle injuries. Because these percentages are similar, both battle and nonbattle injuries were included. Calculations of proportional morbidity were done on Excel spreadsheets.

Historical Data

Review of published modern battle casualty information was undertaken in the collections of the medical library of the National Naval Medical Center and the National Library of Medicine, both in Bethesda, Maryland, and the University of Maryland Health Sciences Center in Baltimore, Maryland. Also, the staff of the historical and rare book collections of both the latter institutions were helpful in locating additional published materials. Unpublished data on major limb injuries and amputations from the Vietnam War Wound Data and Munitions Effectiveness Team (WDMET) database were courteously made available by R. F. Bellamy, COL, USA, MC (ret).

RESULTS

As of June 1, 2006, the JTTR had recorded data on a total of 8058 U.S. military casualties who had been injured severely enough to be admitted to a medical treatment facility with advanced surgical capability and not to be returned to duty within 72 hours. Of these, 5684 (70.5%) were recorded as having 1 or more serious upper- and/or lower-limb injuries (Table 1). As of June 1, 2006, the amputation database recorded 423 individuals with 1 or more major limb amputations, giving an amputation rate of 5.2% as a function of overall serious injuries and 7.4% as a function of major limb injuries. Of the amputees, 372 (87.9%) had an explosive device recorded as their mechanism of injury (Table 2). Of the 12.1% of major limb amputations not associated with explosions, gunshot wounds were by far the most common mechanism of injury (4.7% of all mechanisms of injury).

Of the individuals, 3349 sustained 1 or more serious upper-limb injuries; 3854 sustained 1 or more serious lower-limb injuries; and 1778 sustained serious injury to both the upper and lower extremities. Of those individuals with extremity injury, 3.1% (105/3349) of the upper-limb injuries and 8.5% (328/3854) of the lower-limb injuries resulted in amputation (Table 3). Of these individuals, 535 (15.9%) had an upper-extremity neurovascular injury and 575 (14.9%) had a lower-extremity neurovascular injury. There were 79 service members with more than 1 major amputation (18%). Of these, 67 had bilateral lower-extremity amputations, 6 had bilateral upper-extremity amputations, 10 had 1 upper- and 1 lower-extremity amputation, and 4 had triple major amputations.

The JTTR was also searched for individuals with major traumatic amputations. These are acute amputations that occur prior to reaching definitive care and are not a result of failed limb salvage. This was compared to the MARP database of 423 amputees, which includes all individuals with an amputation, early or late. It was found that 404 patients had traumatic amputations (95%).

TABLE 1. Casualty Data, October 1, 2001–June 1, 2006

Casualties not returned to duty within 72 hours	8058
Casualties with serious extremity injury	5684 (70.5%)*
Upper extremity	3349 (41.6%)
Lower extremity	3854 (47.8%)
Major limb amputees	423†
Upper extremity	105
Lower extremity	328
Amputation per total casualties	5.2%
Amputation per serious extremity injury	7.4%

*Percentage of all casualties not returned to duty within 72 hours.
†Patients with both upper- and lower-extremity amputations are included in both groups.

TABLE 2. Location of Major Amputations and Mechanism of Injury, June 2006

	Mechanism				
Location	Explosion*	MVC	GSW	Other†	Total
Above elbow (AE)	31	3	1	0	35
AE, below elbow (BE)	1	0	0	1	2
AE, below knee (BK)	2	0	0	0	2
AE, knee disarticulation	1	0	0	0	1
Above knee (AK)	77	2	7	3	89
AK, AE	2	0	0	0	2
AK, BK	16	1	0	1	18
AK, BK, BE	1	0	0	0	1
AK, knee disarticulation	5	0	0	0	5
AK, wrist disarticulation	1	0	0	0	1
BE	39	0	1	3	43
Bilateral AK	11	0	0	0	11
Bilateral AK, BE	1	0	0	0	1
Bilateral BE	4	0	0	0	4
Bilateral BK	21	0	0	0	21
BK	125	3	8	9	145
BK, Symes	2	0	0	0	2
BK, knee disarticulation	2	1	0	0	3
Hip disarticulation	7	0	0	0	7
Hip disarticulation, AK	1	0	1	0	2
Hip disarticulation, AK, BE	1	0	1	0	2
Hip disarticulation, BK	1	0	0	0	1
Shoulder disarticulation	5	0	0	1	6
Symes	6	0	0	1	7
Knee disarticulation	6	1	0	0	7
Wrist disarticulation	3	0	1	1	5
Totals (Percent)	372 (87.9)	11 (2.6)	20 (4.7)	20 (4.7)	423

*Explosion: explosive device, landmine, grenade, mortar round.
†Other: fall, fragments, tire explosion, weapon malfunction, crush.

TABLE 3. Upper-versus Lower-extremity Amputations

	Upper Extremity	Lower Extremity
Extremity injuries	3349	3854
Amputees	105	328
Amputation rate per extremity injury	3.10%	8.50%
Neurovascular injury	535 (15.9%)	575 (14.9%)

DISCUSSION

At the outset of every new military engagement, trauma surgeons moving from civilian to military theaters remark on the proportion of serious limb injuries.[1] Serious civilian trauma mainly involves the sharp penetrating stab wounds and individual low-velocity small arms ballistic trauma characteristic of inner-city violence and the blunt trauma associated with motor vehicle crashes. The proportional morbidity associated with high-velocity penetrating ballistic and explosive injuries characteristic of modern military actions and urban terrorist activity can be predicted by the percentage of body surface area exposed. Of primary wounding sites, 50% to 70% are likely to be in the extremities.[2,3] Coupland and Korver looked at landmine injuries in combat situations and found the extremity involved in 75%.[4]

The potential utility of major limb amputation as a life-saving surgical intervention for open fractures and other devastating limb injuries has been recognized through much of written human history. However, the advent of gunpowder onto the battlefields of Europe in the 14th century forced surgeons to solve the problems of, first, hemorrhage and then, as more casualties survived the initial surgery, sepsis. From the American Civil War to the present, the development and need for utilization of amputation as a major surgical technique is characterized by a simultaneous history of remarkable medical and surgical advances coupled with the equally astounding augmentation of the destructive power of battlefield weapons. Lower-limb vascular injuries in World War II required amputation because attempts at vascular repair, particularly of the popliteal artery, had no better, and sometimes worse, outcomes than ligation.[5] By the end of World War II, changes in surgical technique, particularly renewed appreciation for the need for adequate debridement of devitalized tissue and the appropriate adjunctive use of antibiotics, had greatly reduced infection as a cause of surgical amputation.

In military trauma care after World War II, the degree of primary tissue destruction, not infection or isolated nerve or vascular injury, determines the likelihood of the need for amputation,[6] and the degree of tissue destruction is directly related to the forces associated with the dominant weapons in use in any given conflict situation. "…The tactical situation alters the mix of wounding weapons."[7] In general, rapidly shifting ground force tactical situations and urban operations are dominated by small arms fire and a greater proportion of gunshot wounds, and more static situations show increased proportions of wounding by fragments from explosive devices,[8] also known as secondary blast injury. An example is the conflict in Mogadishu, Somalia, October 1993, where a rapidly evolving military urban firefight resulted in 55% casualties from gunshot wounds and 31% from fragment injuries.[9]

Our review of data from the current conflict shows major amputation rates of 5.2% of all serious injuries and 7.4% of major limb injuries. This approximates the reported amputation rate during Vietnam of 8.3% of extremity injuries (Bellamy, unpublished data). Given the limitations of registry data, a review of the JTTR and MARP data suggests that the rate of major limb amputation, as a function of major limb injury, is comparable to that of Vietnam. The initial clinical impression of increased incidence of limb injury and amputation does not appear to be supported by the data. However, this is complicated by the difficulty of comparing casualty statistics from one conflict with another—namely, the problem of dilution of rates by the inclusion of roughly 50% of casualties with less severe injuries in denominators previously used to calculate amputation rates.[10] Further confusion arises from the custom of expressing amputation rates as proportions either of major limb injuries or as proportions of total casualties. For example, Islinger et al, in their review of orthopedic injuries from Grenada, the Gulf War, and Somalia, report amputation rates of 19%, 14%, and 14%, respectively, of all major-extremity injuries for these 3 conflicts and note that these proportions have not changed significantly since the Vietnam War.[11] Their calculations are expressed as the proportion of amputations, not amputees, to the number of major limb injuries, and the source for their data on Vietnam was not cited. In fact, there is no comprehensive epidemiologic summary of military casualties of the Vietnam War. Bellamy and various colleagues have collated and published analyses of data collected by the WDMET of the Army Materiel Command on roughly 8000 U.S. Army and Marine Corps casualties from 1967 to 1969.[7,12] The WDMET is a data subset collection and does not include all casualties of the Vietnam War. These data suggest that major amputations represented about 2.6% of serious injuries (63/2400) among ground personnel in Vietnam, although the true proportion may be more than twice that.[12] According to Internet sources there may be more than 5000 amputees from the Vietnam War, giving an amputation rate of 5.2% of the roughly 96,000 seriously injured casualties.

Several interesting findings in the current data also bear discussion. Of the amputees, 18% had more than 1 extremity amputation and 2.4% had both an upper- and lower-extremity amputation. This represents a significant proportion of the amputees and demonstrates the high level of trauma involved. Multiple limb amputations have been reported to be between 2% and 8% from World War I to the Korean War. During the Vietnam War, 18% of the amputees in the WDMET database had more than 1 extremity amputation and there was 1 triple amputee.[13] The increase in percentage of multiple amputees during the Vietnam War was attributed to rapid helicopter evacuation to a surgical facility. The same high percentage in this current conflict may be a result of rapid evacuation, forward placement of surgical teams, and increased use of tourniquets.[14] There is also an increase in the use of individual body armor that may prevent associated lethal injuries to the chest. It has been shown that the case fatality rate in the current conflict is lower than in any other modern war, 9.4 versus 19.1 in World War II and 15.8 in Vietnam.[13]

Major lower-limb injury is almost three times as likely to result in amputation as major upper-limb injury. This has several possible explanations. The lower extremities are more vulnerable to explosion injuries emanating from the ground as in a landmine-type injury. Explosive devices are commonly used at ground level, creating injuries similar to landmine injuries. Injuries incurred closer to the blast area result in more tissue destruction, making limb salvage more difficult.

Nonunion and infection are also more common in the lower extremity, which could lead to additional late amputations,[15] although we have seen only 5% of amputations performed late. In addition, modern prosthetics in below-knee amputations have given most of these patients excellent function. However, even with modern prosthetics technology, a partially sensate hand with missing fingers is still likely to be more functional than the most advanced prosthetic device. For this reason, every effort is made to preserve the arm and hand, where similarly aggressive efforts in reconstruction of the lower extremity may not be as feasible or even desirable. The difference does not appear to result from the presence of neurovascular injury because the incidence is similar for the upper and lower extremities—15.9% versus 14.9%, respectively. It was found that 95% of major amputations were performed early during the evacuation chain prior to reaching definitive care and were not a result of failure of later reconstructive procedures. The early amputations may have been a result of a traumatic amputation at the time of injury, shear magnitude of soft-tissue injury resulting in a dysvascular extremity, or a lifesaving surgery resulting from uncontrolled hemorrhage. In late amputations performed after the patient has returned stateside, the decision is made after a discussion between the military member and orthopedic surgeon. There is considerable variation in an individual's perception of amputation. Some are adamant about preserving their limb, and others do not want to pursue limb salvage.

Our study is limited by being from registry data. Data are collected, initially under the most austere circumstances, all through the evacuation process and are entered as they become available as a compilation of all military casualties, not as part of one or another precharacterized test cohort. In addition, our calculations of rates are based on data generated during a particular period of an ongoing conflict about which data are still accumulating, so this picture may change. Inclusion of the MARP data, however, has allowed us access to details of injury patterns and surgery not collected by the JTTR and increased the likelihood that our final cohort of amputees from the study period was complete.

SUMMARY AND CONCLUSIONS

Because of the historical differences in determining the number of amputees, number of amputations, and number of casualties, it is difficult to compare amputation rates. The number of amputees has been based on number of limbs amputated and can include less severe amputations, such as fingers and toes. Also, as has been discussed, the number of casualties has included all casualties, casualties with only extremity injuries, and both severe and minor injuries. These differences can greatly affect the calculation of the amputation rate; therefore, exact comparisons between conflicts are difficult to determine.

Amputation rates have remained at roughly 7% to 8% of major-extremity injuries for the past 50 years. This is despite increasingly rapid evacuation of casualties, dramatic improvements in surgical technique, and far forward deployment of specialist care. However, over the same period, the degree of primary tissue destruction associated with modern weaponry has also increased dramatically. As seen in this conflict, more than 90% of the amputations are a result of initial severity of injury or traumatic amputation. Unfortunately, even given the limitations of this registry review, we believe that the rate of amputation following major limb injury is likely to remain unchanged in the current combat environment.

REFERENCES

1. Gawande A. Casualties of war—Military care for the wounded from Iraq and Afghanistan. *N Eng J Med*. 2004;351:2471–2475.
2. Champion HR, Baskin T, Holcomb JB. Injuries from explosives. In: McSwain NE, Salomone J, eds. *National Association of Emergency Medical Technicians: PHTLS Basic and Advanced Pre-hospital Trauma Life Support: Military Edition,* 2nd ed. St. Louis: Mosby; 2006.
3. Champion HR, Bellamy RF, Roberts P, et al. A profile of combat injury. *J Trauma*. 2003;54:S13–S19.
4. Coupland RM, Korver A. Injuries from antipersonnel mines: the experience of the International Committee of the Red Cross. *BMJ*. 1991;303:1509–1512.
5. DeBakey ME, Simone FA. Battle injuries of the arteries in World War II. *Ann Surg*. 1946;123:534–579.
6. Dougherty PJ. War wounds, limb salvage, and traumatic amputations. In: Bucholz R, ed. *Rockwood and Green's Fractures in Adults*. Philadelphia: Lippincott Williams & Wilkins; 2006:482.
7. Bellamy RF. Combat trauma overview. In: Zajtchuk R, Bellamy R, eds: *Textbook of Military Medicine: Anesthesia and Perioperative Care of the Combat Casualty.* Washington DC: Office of the Surgeon General; 1994: 1–42.
8. Reister FA. *Battle casualties and medical statistics; U.S. Army experience in the Korean War*. Washington DC: Office of the Surgeon General; 1973.
9. Mabry RL, Holcomb JB, Baker AM, et al. United States Army Rangers in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma*. 2000;49:515–528.
10. Holcomb JB, Stansbury LG, Champion HR, et al. Understanding combat casualty care statistics. *J Trauma*. 2006;60:397–401.
11. Islinger RB, Kuklo TR, McHale KA. A review of orthopedic injuries in three recent U.S. military conflicts. *Mil Med*. 2000;165:463–465.
12. Martin CH. Vietnam War Statistics. Available at http://www.my.eiis.net/cmart/vietwarstats.html. Accessed June 22, 2006.
13. Mayfield GW. Vietnam War Amputees. In: Burkhalter WE: *Surgery in Vietnam: Orthopedic Surgery.* Washington, DC: Office of the Surgeon General; 1994:131–153.
14. Potter BK, Scoville CR. Amputation is not isolated: an overview of the US Army amputee patient care program and associated amputee injuries. *J Am Acad Orthop Surg*. 2006;14:S188–S190.
15. Dellinger EP, Miller SD, Wertz MJ, et al. Risk of infection after open fracture of the arm or leg. *Arch Surg*. 1988;123:1320–1327.